

Charged jet reconstruction in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC

Jan Rusnak¹

¹*rusn@email.cz, Nuclear Physics Institute ASCR, Na Truhlarce 39/64, 180 86 Praha 8, Czech Republic*

Abstract. Jets represent an important tool to explore the properties of the hot and dense nuclear matter created in heavy-ion collisions. However, full jet reconstruction in such events is a challenging task due to extremely large and fluctuating background, which generates a large population of combinatorial jets that overwhelm the true hard jet population. In order to carry out accurate, data-driven jet measurements over a broad kinematic range in the conditions of small signal to background ratio, we use several novel approaches in order to measure inclusive charged jet distributions and semi-inclusive charged jet distributions recoiling from a high p_T hadron trigger in central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. A very low infrared cutoff on jet constituents of 200 MeV/ c is applied in all measurements. These jet measurements allow a direct comparison of jet quenching at RHIC and the LHC.

1 Motivation

Jets - collimated sprays of hadrons - are well calibrated tools to study the properties of the matter created in heavy-ion collisions [1]. They are created by fragmentation and hadronization of scattered partons generated in hard momentum exchange in the initial stages of the collision. While traversing the medium, they interact with the surrounding hot and dense matter resulting in modification of their fragmentation with respect to the vacuum case (jet quenching)[2]. This modification of parton fragmentation provides sensitive observables to study properties of the created matter.

Jet reconstruction in the environment of a high energy nuclear collision is a challenging task, due to the large and complex underlying background and its fluctuations within an event which can easily disturb measured jet distributions. In order to overcome the obstacles of jet reconstruction in heavy-ion collisions, we utilize two different methods. The first method filters out the fake “combinatorial” jets by imposing a cut on the transverse momentum of the leading hadron of each jet. This procedure however imposes a bias on the jet fragmentation. The second method chooses the hard event by requiring a high momentum hadron trigger. A jet back-to-back to the trigger is then reconstructed. No cut is imposed on the jet constituents (except a low- p_T cut of 200MeV/ c) and the jet fragmentation is therefore nearly unbiased.

2 Analysis

We have analyzed data from 0-10% central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured by the STAR experiment at RHIC during the run 2011.

Jets are reconstructed using only charged tracks recorded by the STAR Time Projection Chamber (TPC). All tracks are required to have $p_T \geq 200$ MeV/ c . Implementation of the anti- k_T algorithm in the FASTJET software [3] is used for jet reconstruction.

The jet resolution parameter R is chosen to be $R = 0.3$. The fiducial jet acceptance is then $|\eta| < 1 - R$ in pseudorapidity and full azimuth.

In the next step, reconstructed jet transverse momentum p_T^{rec} is corrected for the average background energy density

$$p_T^{corr} = p_T^{rec} - \rho \cdot A \quad (1)$$

where $\rho = \text{med}\{\frac{p_{T,i}^{rec}}{A_i}\}$ is the event-wise median background energy density and A is the jet area calculated with the k_T algorithm using the method [4].

2.1 Inclusive Jet Analysis

In order to determine the response of the jet to the presence of the highly fluctuating and complex background we embed a simulated jet with known transverse momentum (p_T^{emb}) into a real event and calculate δp_T as

$$\delta p_T = p_T^{rec} - \rho \cdot A - p_T^{emb} = p_T^{corr} - p_T^{emb} \quad (2)$$

It was shown, that the δp_T distribution is not significantly dependent on the choice of the fragmentation model of the embedded jet [5]. With the knowledge of the δp_T and with use of a Monte Carlo (MC) generator, a response matrix of the system can be calculated which maps the true p_T distribution to the measured one.

A jet momentum distribution is smeared not only by background fluctuations, but also by detector effects. An MC simulation using a parametrization of the TPC tracking efficiency is used to calculate an approximate detector response matrix.

In order to reduce the combinatorial background, a cut on the transverse momentum of the leading hadron ($p_T^{leading}$) of the jet is imposed. Also a cut on the jet area [4] $A > 0.2$ in case of $R = 0.3$ and $A > 0.09$ for $R = 0.2$ is applied.

In the final step, the measured p_T^{corr} distribution is corrected for the background and detector effects

using an iterative unfolding technique based on Bayes' theorem [6].

Results

Figure 1 shows the p_T spectrum of inclusive charged jets in central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV for $R=0.3$ corrected for background and detector effects.

2.2 Trigger Recoil Jet Analysis

A trigger hadron is required to have momentum $9 \leq p_T \leq 19$ GeV/c. A jet is then reconstructed in azimuth ϕ satisfying

$$|\phi - \pi| < \frac{\pi}{4} \quad (3)$$

where the position $\phi = 0$ is defined by the trigger position.

In order to estimate the effect of the presence of the fluctuating background a set of Mixed Events (ME) is created. A mixed event is composed of N tracks randomly picked up from N different, randomly chosen events (however all the N events come from the same centrality bin, z-vertex bin and event plane direction Ψ_{EP} bin). All high- p_T tracks are discarded. Such a mixed event does not exhibit any physical correlations between the tracks; on the other hand it describes the key features of the background (detector acceptance inhomogeneities, total track multiplicity, etc.). The mixed event distribution is then subtracted from the (unmixed) Same Event (SE) distribution.

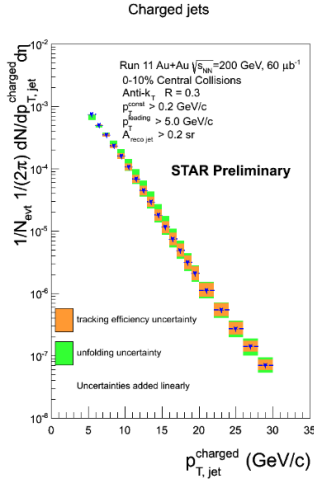


Figure 1. The corrected p_T spectrum of inclusive charged jets in central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV for $R=0.3$.

Instead of correcting the results for background and detector effects by means of unfolding, a simulated PYTHIA p+p spectrum is smeared by these effects. This smeared p+p reference is then compared with the measured Au+Au data.

Results

Figure 2 shows a comparison of the measured recoil jet spectrum (SE-ME) in central Au+Au collisions and smeared PYTHIA p+p spectrum for $R=0.3$. A suppression of the measured spectrum is apparent with respect to PYTHIA.

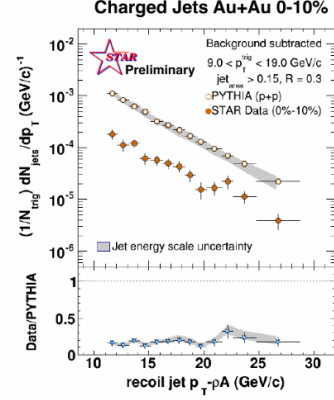


Figure 2. The recoil jet spectrum in central Au+Au collisions and smeared PYTHIA p+p spectrum at $\sqrt{s_{NN}} = 200$ GeV for $R=0.3$.

3 Conclusion

We have presented preliminary results of ongoing jet measurements at the STAR experiment. These measurements utilize low-bias methods of jet reconstruction allowing direct comparison with theory.

We have used a new technique of the mixed events for jet background estimation in heavy-ion collisions.

Further detector corrections and other effects are yet to be included.

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